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Simulation Of Vehicular Movement in VANET

by

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Certificate

This is to certify that the work in the thesis entitled *Simulation Of Vehicular Movement in VANET* by *Amrit Ekka*, bearing roll number 109cs0021, is a record of an authentic work carried out by him under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of *Bachelor of Technology* in *Computer Science and Engineering* at National Institute of Technology Rourkela.

Dr. Ashok Kumar Turuk

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(Amrit Ekka)

Abstract

In the recent years research in the field of vehicular ad-hoc network(VANET) is done extensively. VANET consist of large number of dynamically nodes which are vehicles over a area. Different types of technology and applications are being developed for the VANET . So this VANET technology and applications should be thoroughly checked before deployment in the real world environment. But to test technologies and applications in real world environment is not feasible it involves lot of danger and safety issues, different reports of the testing cant also be generated so to overcome these limitation we need to carry out simulation of VANET in the computer environment i.e. we should do a computer simulation. Computer simulation is risk and danger free, we can generate different scenario (rural, urban, collision of vehicles) of the VANET using this. So computer simulation is very important in VANET research.Simulation of VANET is divided into two part

a. Traffic simulation: Generation of traffic movement, Defining the mobility model for vehicle and creating traffic movement.

b. Network simulation: Generating Inter communicating vehicle , Defining communication protocols.

And both the simulation are connected in bi-directional coupling. ...

***Keywords*:** VANET, SUMO, MANET, Network simulation, Traffic simulation

Contents

List of Figures

List of Tables

Abbreviations

MANET	**M**obile **A**dhoc **NE**twork
VANET	**V**hicular **A**dhoc **NE**twork
PAN	**P**ersonal **A**rea **N**etwork
RSU	**R**oad **S**ide **U**nit
OBU	**O**n **B**oard **U**nit
WAVE	**W**ireless **A**ccess for **V**ehicular **N**etwork
SUMO	**S**imulation of **U**rban **M**obility
VEINS	**VE**hicle **I**n **N**etwork **S**imulation

Chapter 1

Introduction

Wireless Ad-hoc network is defined as a network which doesnt have a preexisting communication infrastructure. Network is created by some nodes which are available. In this type of network determination of which nodes to transfer data to which node is done dynamically, depending upon the connectivity of both devices. Ad-hoc network can use flooding data transfer. In Ad-hoc network all devices are treated equally all have same status. The main use of wireless ad-hoc network is done by Mobile Ad-hoc Network (MANET). In MANET different participating node moves randomly in the created wireless Ad-hoc network.

1.1 MANET

We know that in MANET nodes moves randomly in the wireless Ad-hic network. Since here devices moves dynamically in the network so the connecting link between two devices changes frequently it makes building MANET very challenging. The main challenge of building MANET is to manage continuous change of route traffic.

The figure1.1 [15]shows how data is forwared form souce to destination detecting connectivity between two device.

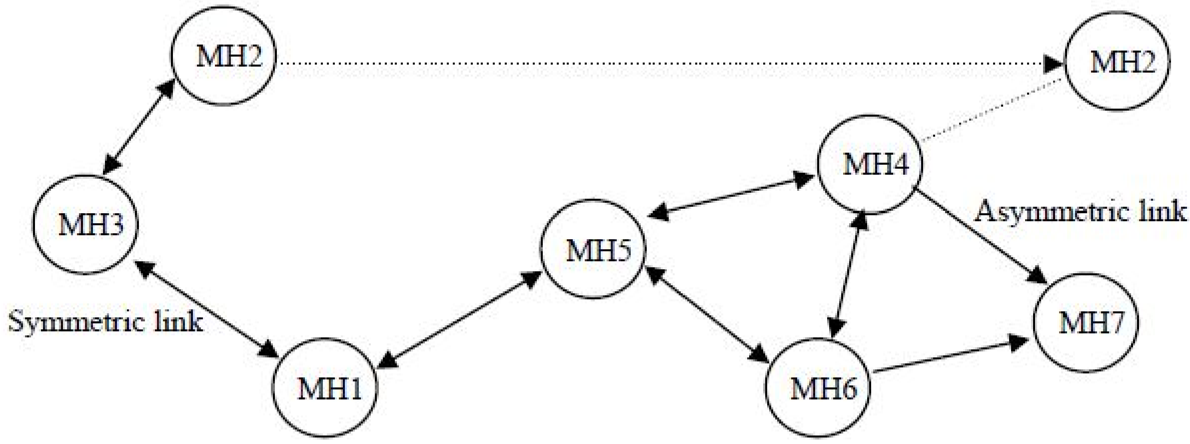


FIGURE 1.1: Mobile Ad-hoc Network [15]

1.1.1 Application of MANET

There are many applications to ad-hoc network. In ad-hoc network any node can be gateway for web services. There are many military application possible with Mobile Ad-hoc network ,for example in battle field in unknown territory it is impossible have wired network for MANET can be very effective in here. Some of the main application of MANET are:

- Collaborative Work in corporate environment many projects are done collaboratively and its need to work outside office in this case MANET can be very useful by this ad-hoc network can be created between office device and devices present outside.

- Crisis-Management Application In a natural disaster happens the communication infrastructure can get damaged. In this case setting up wired network will take lot time but aadhoc network can easily be created with in limited time.

- Personal Area Networking A personal area network (PAN) is a localized a short range network associated with person. This network can include devices link PC, smartphone, printer, watch, AC, switches, doors. So in device lots of mobility happens to accommodate mobility mobile ad-hoc network is used.

- Vehicular Ad-hoc network In recent year vehicular ad-hoc network (VANET) is hot research topic. In VANET moving nodes are vehicle moving on road. VANET can be used to improve the safety in the road.

Among the different type of MANET the most popular is Vehicular ad-hoc network (VANET) it used for communication between different vehicles running on traffic and road side infrastructure .We can also say that VANET are Subset of MANET where communication nodes are mainly vehicles.

1.2 VANET

Now a days most modern car have intra vehicular network which allows wireless communication between vehicle and electronic gadets like smart phone ,Global Positioning System (GPS) ,Bluetooth media players. But the Inter vehicular communication network is still not available. So to provide inter vehicular communication VANET i.e. Vehicular ad-hoc Network technologies are emerging.

Vehicular ad hoc networks (VANETs) are defined a as subset of mobile ad hoc networks (MANETs) with the distinguishing property that the nodes present in here are vehicles. So node i.e. vehicle movement is restricted by road course, encompassing traffic and traffic regulations. Because of these restrictions VANET is supported by some fixed infrastructure that assists with some services of the VANET and provides access to stationary networks. The fixed infrastructures are deployed at critical locations like road sides, service stations, dangerous intersections or places with hazardous weather conditions.

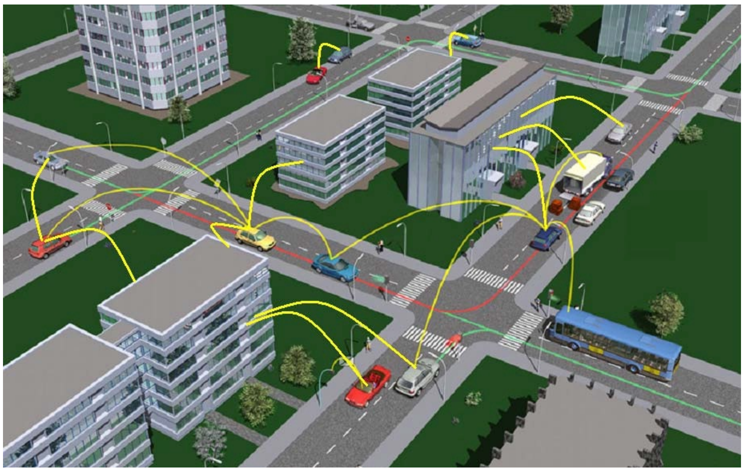


FIGURE 1.2: Vehicular Ad-hoc Network [16]

The figure 1.2 [16] describes how Vehicle communicates with each other and with fixed infrastructure.

1.2.1 Specific Characteristics of VANET

High Dynamic Topology : VANET have very high dynamic topology .The communication links between node changes very rapidly. Communication between two nodes remains for very less time. For example if two vehicles moving away from each other with a speed of 25m/sec and if the transmission range is about 250m, then the link will only last for only 5 seconds (250m/ 50ms-1). So this how highly dynamic topology is present in VANET

Frequent disconnected Network : From the above characteristic we can see that connection between two or more vehicle remains for 5 second or so. To maintain the continuous connectivity vehicles needs another connection nearby immediately. But if failure occurs vehicles can connect with Road Side Unit (RSU). Frequent disconnected network mainly occurs where vehicle density is very low like rural area.

Mobility Modelling and Prediction : The above two features for connectivity needs the knowledge of positions of vehicles and their movements but this is very difficult to predict since vehicle can move randomly and it doesnt have a pattern. So mobility models node prediction which based on the study of predefined road roadway model and vehicle speeds are use.

Communication Environment : The mobility model highly varies in different environment form rural area to urban area, from highways to that of city environment. So mobility modelling and vehicle movement prediction and routing algorithm should adapt to these changes. For highways mobility models are very simple because vehicle movement is one dimensional. But in case of city environment lots of vehicle present different obstacle like building are present it makes communication application very complex in VANET.

Hard Delay Constraints : Safety aspect like accident, sudden break and emergency call of VANET application depends upon the deliver time of data. It cannot compromise for data delay in this type of application. Therefore hard delay constrain is more important in VANET than high data rate.

Interaction with on-board sensors : The on-bard sensor are present in the vehicle. These sensors are used to find vehicle location, vehicle speed and vehicle movement these informations are then used for effective communication between vehicles.

1.2.2 Applications Of VANET

The primary goals of VANETs are to improve safety on the road. To achieve this, the vehicles act as sensors and exchange messages to different vehicles this messages include information like speed of vehicle, condition of road, Traffic density. This enables the drivers and authorities to react early to any dangerous situations like accidents and traffic jams. But the recent research in the field of VANET have discovered many applications and technologies.

Type-1:Application Assistance for Safe Navigation

This applications manages different critical aspects of traffic safety. Several services can be offered, among them are the following:

- Application for avoiding collision through distance calculation between two vehicle it can use sudden braking system.
- Application for detection of hazardous and dangerous driving conditions. This conditions can be damaged road, blocked road, if road is covered with snow or mud.
- Application for emergency call services after an accident occurs here the vehicle can automatically call to authority if an accident occurs.
- Applications for detecting rogue drivers which are disobeying traffic rules like crossing speed limit, talking in phone while driving, driving in the wrong side of the road.

Type-2:Application for Traffic Regulation and Internet Connectivity

The second types of applications are the following:

- Application forAdvanced Navigation Assistance (ANA) such a car park formation, real time vehicle congestion information, expected weather condition for driving , etc.,
- Internet connection services can be provided to vehicle added for travel comfort and improved productivity. This be done by data transfer between vehicle and road side unit.

- Chatting services between users of the same root, This can improve driving safety one driver can send immediate warning message to other driver, and
- Application for advertisement of local/nearest service stations, nearest hotel, shops, mall.

1.2.3 Challenges faced by VANET

There are many challenges which are faced by VANET. These challenges are technical challenges as well as business challenges. Now we will see what these challenges are in following paragraph and in next chapter how we can overcome this challenges using simulation.

1.2.3.1 Technical Challenges

There is no particular transport protocol created for vehicular networks so far, and it is very complex to design new protocols or to adapt existing protocols by modifications.

The transport of messages between noses should be completely error free because their will most likely be no time to retransmit the message, especially in emergency situations like accident. Tis messages are very critical to transmission of message should happen with in an instant so transport of message should be error free and read with time. Most often, transport messages must be error free because a message will not be able to be retransmitted in the case where two cars are passing each other while going in opposite directions that can after some time two cars will be out of connection range.

VANET will have to enhance its transport layer protocols from currently used protocols in ad hoc network transport technologies. We have to use a specialized protocol designed for VANET other than TCP. The current challenges that are needed to be overcome to create a successful transport protocol are because of long round trip times, high packet loss rates, high probability of packet reordering, and short connection durations are present in current ad hoc networks. Vehicular ad-hoc networks add to the complexity due to the fact that the nodes are travelling at high rates of speed.

Overall, VANETs must work in all type of traffic i.e. high and low vehicle density environments in urban and rural environment respectively. This creates a challenge for the hardware design for VANETs. Because for example in low density vehicle environment the number of vehicle will be less so some vehicles will be out of rang for communication. In high density vehicle environment sharing of bandwidth is a challenge for VANET.

1.2.3.2 Business Challenges

The main business challenge for VANET is to create of a new market. Also, all potential of VENET may not be realised by customer, so proper advertisement and awareness must be spread.

One other business challenge for VANET is there will be old vehicles in road which are not equipped with VANET, only newer vehicles will be equipped with the VANET.

Chapter 2

Simulation Theory

In the previous chapter we have seen many challenges faced by VANET, many application and technologies are being developed to overcome this challenges. So these applications should be thoroughly checked before deployment in the real world environment. But to test this application in real world environment it is not possible, because this testing involves many safety issues and possess danger. So to test this applications Computer simulation is used. It is very feasible, cost much less, possess no danger and we can also automatically generate reports of different aspect of application.

VANET simulation is different from MANET (Mobile Ad Hoc Networks) simulation because, in VANETs, the vehicular environment has new challenges and requirements when compared to MANET environment, in VANET simulation we have to include factors like road topology, roadside obstacle, varying speed and mobility of vehicle, driver behavior, traffic light, and traffic congestion.

In this chapter we present some challenges faced for VANET simulation, existing mobility models which represent the realistic behaviour of vehicle, we also review the VANET standards, and study and compare different software available for VANET simulation.

2.1 Challenges for realistic VANET simulation

Simulation of VANET involves large number of node when compared to the MANET. Here in this section we represent some challenges which are faced by VANET.

- Accurate and realistic topology of maps: VANET have to include accurate topology for the simulation. These street topologies should manage different densities of intersections, contain multiple lanes information, different categories of streets and speed limitations.

- Obstacles: VANET have to face many obstacle obstacles this obstacle includes hurdles in vehicular movement and vehicular communication. For example when wireless signal passes through specific environment such as building or mountain signal may get disrupt.

- Vehicles characteristics: In realistic environment each category of vehicle has its own characteristics of driving, So VANET simulation have to correctly represent this characteristics. For example trucks are not allowed in some particular times, Buses have to move in some predefined lane. Moreover speed capabilities of a car or a bus or a trucks are different from each other. So VANET simulator has to take all these characteristics in account.

- Trip motion: Trip is defined as a path form source to destination. There may be may trip available for same source and destination. The trip selection changes according to the interest of drive. So VANET simulation have to take drivers interest in account.

- Path motion: A path is defined as the set of road segments taken by a car on its trip between an initial and a destination point. Drivers choose their paths according to a set of constraints such as time of the day, speed limitations, road congestion, distance, and even the drivers' personal habits.

- Smooth deceleration and acceleration: vehicles do not abruptly break and accelerate and crosses the speed limit. Models for decelerations and accelerations should consequently be considered according to type of vehicle.

- Human driving patterns: drivers give response to their environments, not only with respect to static obstacles such as buildings , but also to dynamic obstacles, such as neighbouring cars and pedestrians. So mobility of models of simulator have to behave according these properties.

- Intersection Management: Intersection management in one of the challenges for the VANET simulation there are many ways to control the intersection vehicle have to look at traffic density or look at traffic light. Simulation have to differentiate between all of them.

- Time patterns: Traffic density re different during different time of the day. Simulation have to differentiate between rush hour and normal hour, occasion of specific event. This constrain can change the trip and path selection of a vehicle.
- External Influence: VANET have to take external influences in to account. These external influences can be temporary road works, blockage due to accident, Communication networks are used to find the external influence.

So for more realistic VANET simulation model should include more building parameter. More parameter will provide more realistic simulation. Major parameters are topology maps, driver behaviour.

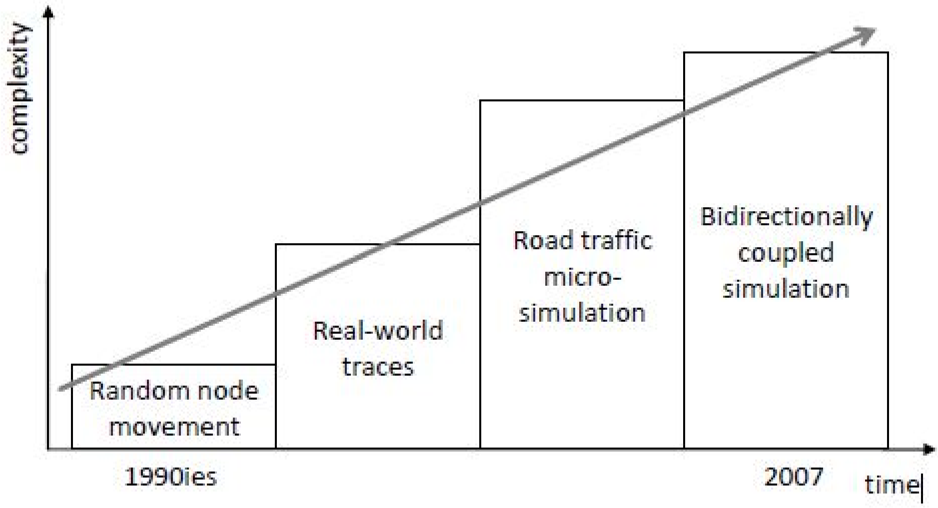


FIGURE 2.1: Evolution of mobility modeling strategies and techniques in VANET research [12]

2.2 Mobility Modeling

The evolution of VANET mobility models used in simulations of protocols and application is given in Figure 2.1 [12]. Early simple models like random node movement were developed and used. But these mobility models do not realistically reflect mobility of car on roads, more complex solutions have been developed based on real-world and artificial traces of car movements up to recent advances based on tightly coupled road traffic micro-simulation and network simulation, Traffic simulation and network simulation are described in next chapter.

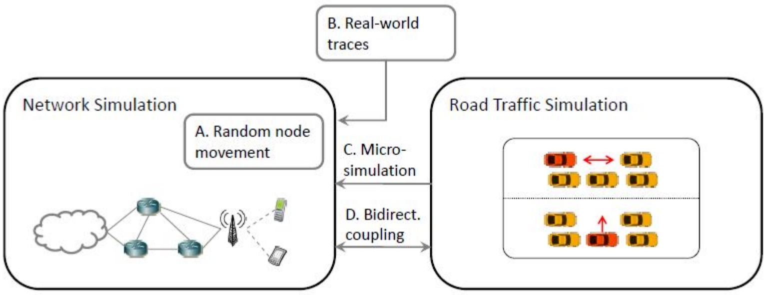


FIGURE 2.2: Mobility modeling techniques for simulation of VANET protocols and applications [12]

TABLE 2.1: OVERVIEW OF MOBILITY MODELS, THEIR LEVEL OF SUPPORT IN SIMULATION FRAMEWORKS, AND THEIR PARTICULAR ADVANTAGES AND DRAWBACKS [12]

Mobility Model Class	Integrated Framework support	Advantages	Drawbacks
Random Movement	Virtually All	Straightforward, intuitive and Readily available	Imprecise and Potentially unstable
Real-World Traces	GloMoSim, QualNet, OPNET, ns-2, Shawn, JiST/SWANS, OMNeT++/INET Framework	Most realistic node movement and Reusable traces	Costly and time-consuming and No free parameterization
Artificial Mobility Traces	GloMoSim, QualNet, OPNET, ns-2, Shawn, JiST/SWANS, OMNeT++/INET Framework	Realistic node movement, Free parameterization and Reusable traces	No feedback on driver behaviour
Bidirectionally Coupled Simulators	ns-2, Shawn, JiST/SWANS, OMNeT++/INET Framework	Realistic node movement, Free parameterization, Feedback on driver behavior	No re-usable traces

Figure 2.2 [12]displays an architecture VANET simulation using network simulation and traffic simulation. Bi-directionally coupled simulation relies on intensive intercommunication of the different simulation tools using appropriate interface. In the following, different mobility models have described following historical time line. All the models are summarized in Table 2.1[12] .

2.2.1 Random Node Movement

In the early days of ad hoc network research, for the movement of nodes in an unconstrained, completely random manner, termed the Random Waypoint mobility model .In this type of models vehicle move randomly without any restriction.

Random Waypoint based mobility models provides different results from more sophisticated vehicular mobility models, sometimes it do not reach a steady state. Its derivatives have been in use in the sophisticated mobility models. For example if we consider inertia or the constraining of vehicles to predefined roads, it will provide more realistic movement patterns and gives different results than a plain Random Waypoint model

2.2.2 Real-world Mobility Traces

In real world Mobility tracing models pre-recorded real world mobility traces are used to creating a mobility models Compared to the use of random waypoint mobility models, Real-World mobility traces more realistic vehicle simulation.

These traces are recorded e.g. form Vehicle observation or by using Global positioning system (GPS) information. In the case of most approaches, real-world vehicles were tracked by regularly recording vehicle positions .These mobility traces were then post-processed and stored in the database. These traces are the used during Network simulation, it controls node movement by reading trace files and synchronizes the node position with the vehicle location.

Theses mobility model may produce more realistic mobility but it is limited by very less mobility parameter. In these we have change trace file for every different scenario, e.g. the density of vehicles, and keeping all other parameters unchanged is simply infeasible in reasonably large scenarios.

2.2.3 Artificial Mobility Traces

In real-world mobility there is restriction on trace data on what could be recorded from real-world vehicle movements. This limitation we can overcome by generating tracing file artificially. These type of mobility models are called Artificial Mobility Traces model.

Artificial mobility models have the advantage of providing simulations with very realistic mobility traces while freely adjusting the mobility parameters at same time so that influence of parameter can be examine on output.

2.2.4 Bi-directionally Coupled Simulators

In any case of communication in VANET for example accident information, road blockage information, hazard condition warning require loop between traffic simulation and network simulation to be closed. For this purpose intensive cooperation happens between different simulation, So this type of simulator are called bi-directional simulator. These type of simulator have recently been developed.

In these simulations, two processes runs concurrently that are process of the network simulator and the road traffic simulator. Both processes exchange information like position and speed of simulated vehicles, Data like radio state are present in network simulator where as planned route is present in the road traffic simulator. In formation exchange takes place in regular interval.

2.3 Routing Protocols

Now different leading car manufactures collaborated with USA government agency to develop communication protocol specially dedicated for the Vehicular communication. Outcome of this collaboration is a wireless access called Wireless Access for Vehicular Environment (WAVE) dedicated for to vehicle to Roadside and vehicle to vehicle communication. It major objective is to improve the safety on the road but also takes care of traffic management as well as on-board entertainment application. When vehicles are equipped with WAVE communication device it is called as VANET.

We know that VANET are subset of MANET, there are plenty of routing protocols developed for MANET but these usually do not apply for the VANET because it has very high mobility and network gets frequently disconnected.

Routing protocols manages how information exchange happens between two communication entities, this management is done by establishing a route, decision in forwarding data, maintaining the route and recovery of failed route.

In VANET, the routing protocols are classified into five categories[14]: Topology based, Position based, Cluster based, Geo-cast and Broadcast. Table2.2 [14] present comparision of various protocols.

2.3.1 Topology Based routing protocols

Topology based routing protocols gets the information of the route the topology of the network. We can further divide this protocol into two category.

1. Proactive
2. Reactive

2.3.1.1 Proactive routing protocols

The main distinction of proactive routing protocols is that irrespective of communication request, the routing information like next forwarding hop is maintained in the background. The data packets are constantly flooded into different node to maintain the path and then using these information a table is created which contains data about next hop to reach a certain destination. The main advantage of proactive routing is that we do not have do a route discovery route information can be directly derived from the table.
One example of proactive routing protocol is given below:
Fisheye state routing (FSR):
In Fisheye state routing every nodes creates a topology table(TT) based on the information which are given by neighbour and it also share information if TT whit its neighbour. Routing tables are different for different destination. The problem with FSR in if the size of network increases the size of table will also increase so it will be very complex to maintain tables. If mobility increate the accuracy of route between node to destination will decrease.

2.3.1.2 Reactive routing protocols

Unlike proactive routing protocols here route opens only when it necessary for communication between two nodes. So this type of protocols are also called as On Demand routing protocols. It maintains routs which are in use, So burden on large network decreases. Here very large networks are also easily maintainable. Reactive protocols have a phase of searching route, this usually done by flooding, this phase ends when the route found. One example of proactive routing protocol is given below:

Temporal Ordered Routing Algorithm(TORA) :

TORA is link reversal routing algorithm it builds a directed cyclic graph according to which it directs the flow of packets and ensures its reaches to all nodes. To construct a directed node broadcasts query packets. If an receive query packet, if node has a link to destination it will again broadcast a reply packet; which acknowledges the link . It constantly updates graph information in regular interval.

2.3.2 position based routing protocol

In position based routing protocols the determination of route is done by information of geographical position of different nodes. Here source inters the information of destination in the node of the packet. The source sends the packet to next hop which is closest to the destination. The main advantage of these protocols is that we do not have to maintain information about route from a source to destination. These protocols are mainly dived into two category:

1. Position based greedy V2V protocols
2. Delay Tolerant Protocols

2.3.2.1 Position Based Greedy V2V Protocols

In greedy algorithm the source and intermediate nodes sends, the packets to the farthest node in the direction of destination. The main aim of these protocols is to decrease the time to for packet transmission, and so are called as Min delay routing protocols. Various types of Position based greedy V2V protocols are GSR, GPSR, CAR, GPCR, STBR, ASTAR, CBF, SAR, DIR and ROMSGP. One example is given below:

Geographic Source Routing (GSR) :

The GSR are imported from MANET use to VANET use by incorporating in to it greedy forwarding of messages toward the destination. It uses a specific mode called Perimeter Mode for recovery if next hop node is not found. It uses static street map and location information about each node, because it do not consider vehicle density in road so this not a efficient method.

TABLE 2.2: Comparison of Various Protocols [14]

Protocols	Proactive Protocols	Reactive Protocols	Position based Greedy Protocols	Delay Bounded Protocols	Cluster Based Protocols	Broadcast Protocols	Geo cast Protocols
Prior Forwarding Method	Wire less multi hop Forwarding	Wire less multi hop Forwarding	Heuristic Method	Carry and Forward	Wireless Multi hop Forwarding	Wire less multi hop Forwarding	Wire less multi hop Forwarding
Digital Map Requirement	No	No	No	No	Yes	No	No
Virtual Infrastructure Requirement	No	No	No	No	Yes	No	No
Realistic Traffic Flow	Yes	Yes	Yes	No	No	Yes	Yes
Recovery Strategy	Multi Hop Forwarding	Carry and Forward	Carry and Forward	Multi hop Forwarding	Carry and Forward	Carry and Forward	Flooding
Scenario	Urban	Urban	Urban	Sparse	Urban	Highway	Highway

2.3.3 Broadcast Routing

Broadcast routing is frequently used in VANEs if there is no direct path is present, it uses multi hop. It uses flooding and send packets to all the nodes. These protocols are used in VANET for sharing traffic, emergency, and weather information. Since it send packet to all the nodes lots of bandwidth are lost. Broadcast routing protocols are BROADCOMM, V-TRADE, DV-CAST and UMB. One example is given below:

2.3.3.1 BROADCOMM Routing Protocol

Hierarchical structure of highway road network is basis of BROADCOMM protocol. It uses flooding for broadcasting messages. It divides highways into virtual cell which behaves like a vehicle; It organizes high ways in two level, one level represent all vehicle in a cell and other level include vehicle present close to centre of a cell.

2.3.4 Geo-cast Routing

It is a type of multi cast routing which is based in geographical location. It delivers packet to all nodes which are present in a geographical region. The vehicles which are not present inside certain geographical region does not gets the warning messages. It floods the message to node defined by forwarding zone. Its main disadvantage is that it is unfavourable to the neighbour. The various Geo-cast routing are DRG, DG-CASTOR and IVG.

Chapter 3

In this chapter we describe how simulation is done and what the results of the simulation are. The simulation is done in 2 phases and two different simulator have been used One is SUMO(Simulation of Urban Mobility) for road traffic simulation and Veins(Vehicular environment in Network Simulation) for network simulation.

3.1 Traffic Simulation

For simulation of Road traffic simulator used is SUMO (Simulator for Urban Mobility). Lets see about sumo.

3.1.1 SUMO (Simulation of Urban Mobility)

SUMO is open source and highly portable road traffic simulator, it can handle very large network. It uses microscopic and continuous mobility model. It was developed by Institute of Transportation Systems at the German Aerospace Center [13].

Since SUMO uses microscopic traffic simulation, each vehicle have explicitly defined, each having unique path an indentification. Each vehicle can be further defined by Origin destination metrics (O/D matrics) this matrics contains information about source and destination. Trip file can be generated from o/d matrics usind od2trips.

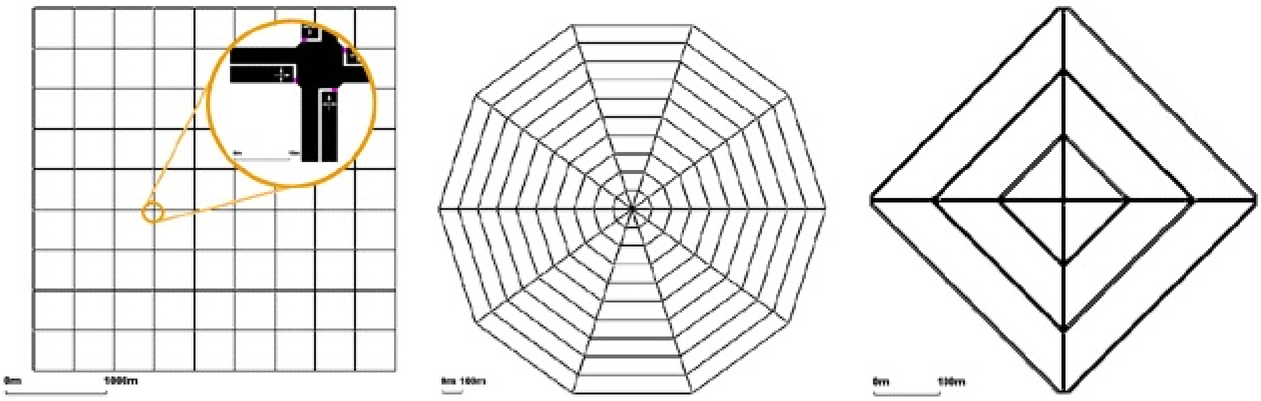
For simulation SUMO need network file to the road network.

Now we will discuss how network file is created. Network files define the road map ion which the vehicle runs. Network file generation have following phase.

3.1.2 Importing map

Although we can manually generate network file by writing route, but this networks are very primitive and it is very difficult to create complex networks. Fig 3.1 [17] shows some manually created networks.

FIGURE 3.1: Network file created manually (a) Grid network (b) and (c) Spider Networks [17]



(a) (b) (c)

But for the realistic simulation we have to create network file which are present in the real world for that purpose SUMO incorporate by which we can download real world road map Form the openstreetmap.org fig3.2 show map from openstreet.org

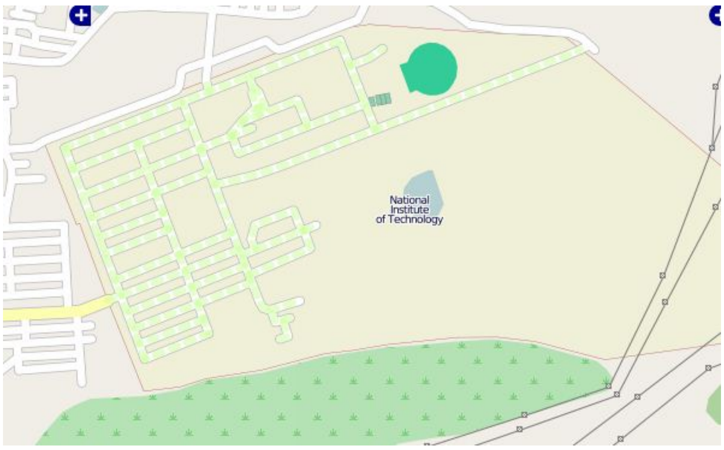


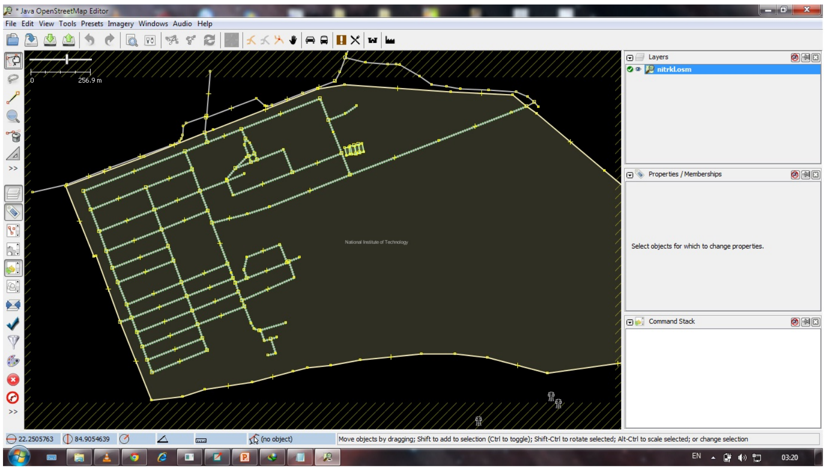
FIGURE 3.2: Map form open street Org

The map are downloaded are OSM file, after downloading map from the website the OSM file edited using JOSM Java OpenStreetMap Editor . IN this process all the unwanted route and path are removed to simplify the network file.

3.1.3 Generation of Network file

After editing the OSM file it is ready to create network file. To convert the .osm file to .net.xml file netconvert command line application is provide by SUMO. It takes .osm file as input and gives .net.xml as output file.

Figure 3.3 shows how transition of .osm file to network file

(a) 

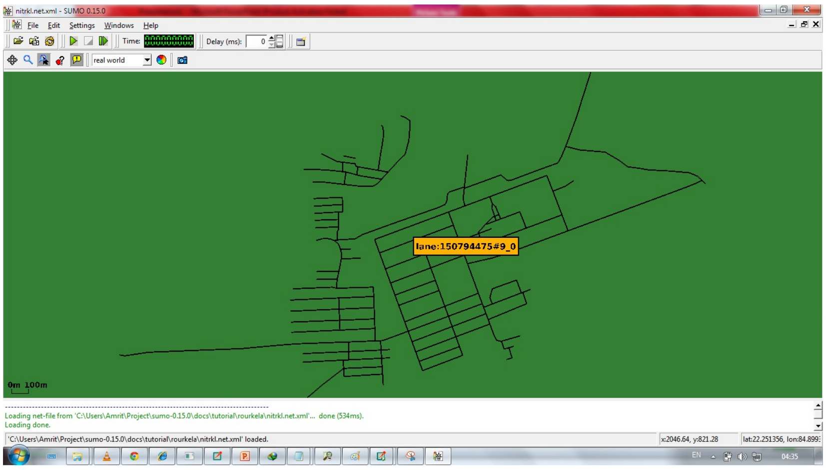
(b) 

FIGURE 3.3: OSM file to Network file (a) OSM file JOSM editor (b) Network file running in SUMO

3.1.4 Network file

Snapshot of network file is given in figure 3.4

Here we can see there are different attribute of network file which are

```
<edge id=":1635542846_0" function="internal">
    <lane id=":1635542846_0_0" index="0" speed="13.89" length="4.82" shape="0.29,251.55 -1.08,250.95 -1.62,250.21 -1.36,249.33 -0.29,248.30"/>
</edge>
<edge id=":1635798389_0" function="internal">
    <lane id=":1635798389_0_0" index="0" speed="13.89" length="0.10" shape="1656.34,374.14 1656.34,374.14"/>
</edge>
```

Figure 3.4: Network file snapshot

Edge defines the connection between starting point of road to ending point of road.

Parameter of edge is given bellow:

Id - It gives unique id to each edge

From - Id of node where edge start

To - Id of node where edge ends

Each edge have definition for lane, lanes have following parameter.

Id - Unique id of the lane

Index - It defines sides of the lane 0 for right.

Speed - Maximum speed a vehicle can travel in it

Shape - It includes set of coordinate of centre line of lane.

3.1.5 Trip file

After creation of network file we have to define route for the vehicle along which vehicle would travel. For this purpose we have to follow two phase one is creation of trip file and using trip file we generate route file for vehicle.

```
<trip id="t0" depart="0" from="-150794518#0" to="150794513#0" />
<trip id="t1" depart="1" from="150794541#0" to="150794526#0" />
```

Figure 3.5: Trip file snapshot

From the figure 3.5 we can see that trip file very simple file it contains the parameters like route id and departure id of vehicle and then starting lane to ending lane.

Since creating trip file all lane is very tedious task for this purpose SUMO provides a python script RandomTrips, by using this script we can create random link between two nodes. This script doesnt see if the lane are connected with each other.

3.1.6 Route file

Route file contains information route a vehicle would travel in a network figure 3.6 shows the snapshot of route file.

```
<vehicle id="t0" depart="0.00">
    <route edges="-150794518#0 150794475#5 150794475#6 150794528#0 150794528#1 150794469#4 150794513#0"/>
</vehicle>
<vehicle id="t1" depart="1.00">
    <route edges="-150794541#0 150794475#9 150794475#10 150794475#11 -150794526#1 -150794526#0"/>
</vehicle>
<vehicle id="t2" depart="2.00">
    <route edges="-150794514#1 -150794464#1 -150794464#0 -150794526#0"/>
</vehicle>
```

FIGURE 3.6: Route file snapshot

For simple file we can easily write the route file but for very large network with high density vehicle it is not possible to write routing file manually. So the trips file along with the network file is now used to generate the vehicle routes is created using the Duarouter.exe application which is a part of the SUMO package.

Parameters of route file are, Vehicle id and departure id, Series of lanes id that the vehicle should follow. So this series of lane id creates a path for the designated vehicle.

3.1.7 Configuration file

Each scenario in sumo has a .sumo.cfg file associated with it which points to the corresponding network and routing files to be used, and also the start and end time of the simulation. This is configuration file.So configuration file is created using combining network file and route file.

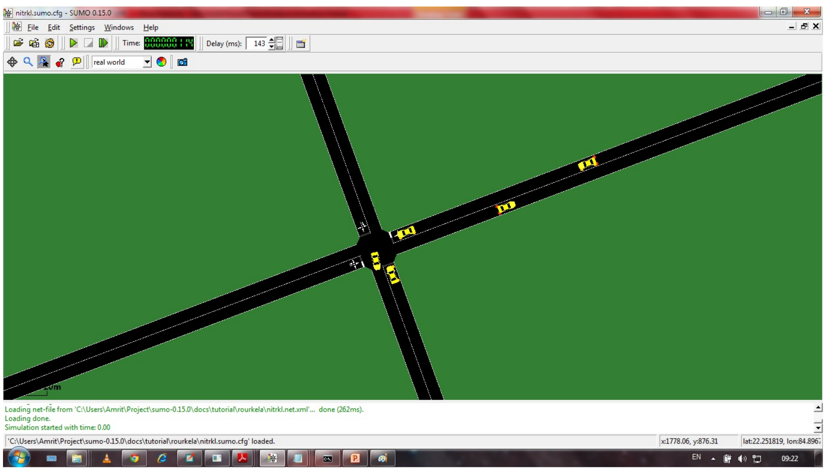


FIGURE 3.7: Movement of vehicle in sumo(Traffic simulation)

Figure 3.7 shows simulation which is done using configuarion file which contains both road network information and vehicle path information .Krauss Car Following model is used in this model Car following model has different set of parameter like acceleration of and deceleration of vehicle , Minimum gap between two vehicle, Driver reaction time.

3.2 Network simulation

After traffic simulation the next phase is to simulate network Network simulation is used to model computer network configurations before they are deployed in the real world. By using network simulation different network setups are compared, making it possible to recognize and resolve performance problems in network without the need to conduct potentially expensive tests in real world. Many opensouce network simulators available like ns-2 , Omnet++, J-SIM. Here in this project we have used the simulator OMNET++ with Veins frame work.

3.2.1 OMNeT++

OMNeT++ is a discrete event simulator used for modeling communication networks, multiprocessors and other distributed or parallel systems. It is based in C++. OMNeT++ model consist of different modules which communicates with each other using message passing, these modules are written in C++. Simple moduses are used to create lager modules [18].

Simulation models in OMNeT++ are described in NED language, NED stand for Network Description. Using Ned language we can crate simple modules after that we can connect assemble these simple modules to create compound module.

OMNeT++ in itself is not a simulator it provides mechanism to write simulator. So network simulation is done by different simulation models and framework like MiXiM, INET/INETMANET or VEINS.

Here we have used Veins for simulation purpose.

3.2.2 Veins

Veins module is avilabe in MiXiM frame work here MixiM provides communication module and protocol . Veins stand for Vehicle in Network Simulation. Veins is an open source Inter-Vehicular Communication (IVC) simulation framework composed of an network simulator and a road traffic microsimulation model.

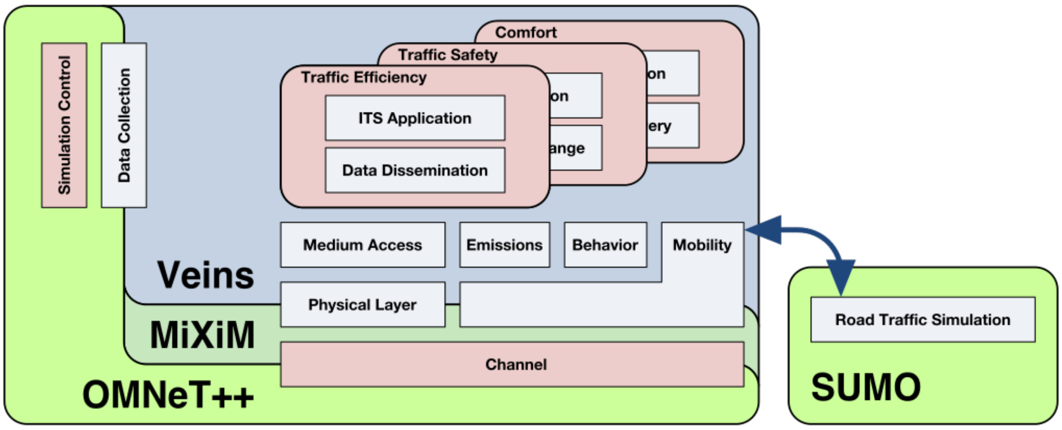


FIGURE 3.8: Veins Architechture [19]

Veins is made up of two distinct simulators, OMNeT++ for network simulation and SUMO for road traffic simulation. To perform IVC evaluations, both network and traffic simulators are runs in parallel, connected via a TCP socket. The protocol for this communication is Traffic Control Interface (TraCI). This allows bidirectionally-coupled simulation of road traffic and network traffic this is described in next section . Movement of vehicles in the road traffic simulator SUMO is reflected in movement of nodes in an OMNeT++ simulation.

3.2.3 simulation

To access the network file and routing file create in the traffic simulation .launched.xml file is created. Figure 3.9 shows snapshot of this file

```
<copy file="nitrkl.net.xml" />
<copy file="nitrkl2.rou.xml" />
<copy file="nitrkl.sumocfg" type="config" />
```

FIGURE 3.9: launchd file snapshot

From the figure we can see that it incorporates network file, route file and configuration file created during traffic simulation.

The simulation in OMNeT++ is controlled by supplying the required modifiable parameters per module that is being used in the simulation using the .ini file corresponding to the simulation. .ini file of simulation contains information about playground size ,launchd file for accessing traffic simulation

Playground size defines the size of simulation area, given values are

playgroundSizeX = 5500m
playgroundSizeY = 5500m
playgroundSizeZ = 50m

.ini file also contains the information of physical layer and application layer which are used

IEEE 802.11p is an amendment from the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE). This protocol is used in physical layer.

Mobility model used is TraCIMobility

3.3 Combining Both network

To complete the simulation both traffic and network simulation should interact with each other this is done by veins. In Veins the communication is standardized as the Traffic Control Interface (TraCI). Tis protocol allows bi- directionally coupled simulation of traffic and network. Both the runs in parallel, connected via TCP socket as we can see in Figure 3.10 [19].

The SUMO Traffic Control Interface (TraCI) modules for OMNeT++ come with a small daemon to make running coupled simulations easier This daemon, sumo-launchd, is designed to run in the background, listening for incoming requests. On each incoming connection, it receives the simulation setup in XML format, then launches a separate

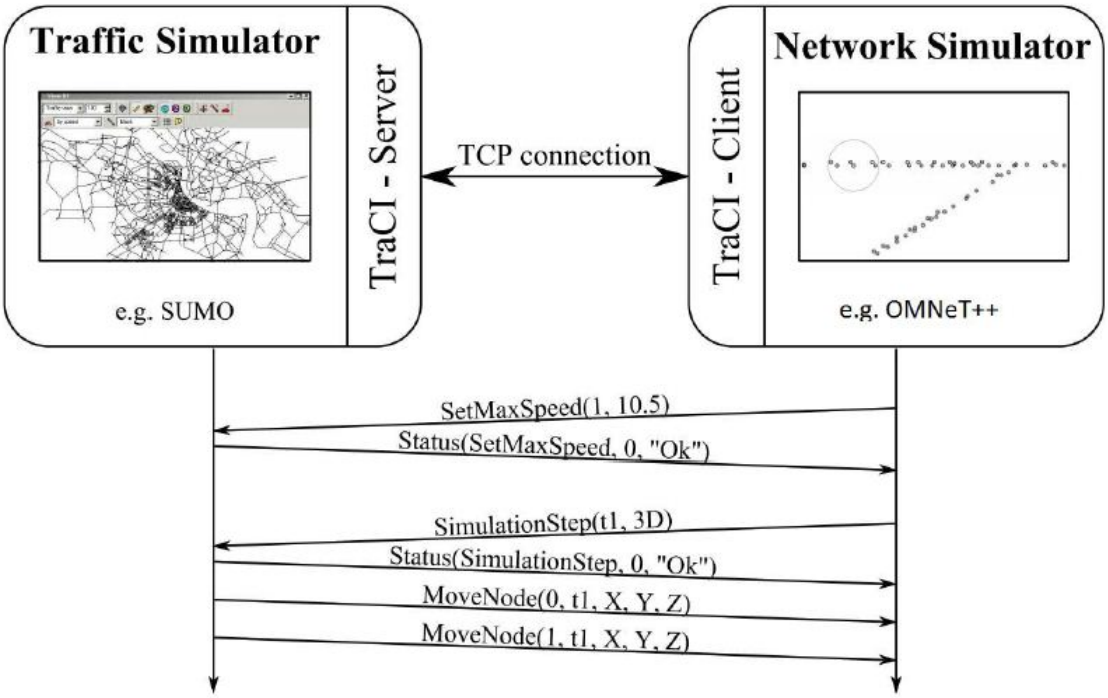


FIGURE 3.10: Network Simulator OMNeT++ coupled with Traffic simulator SUMO using TraCI [19]

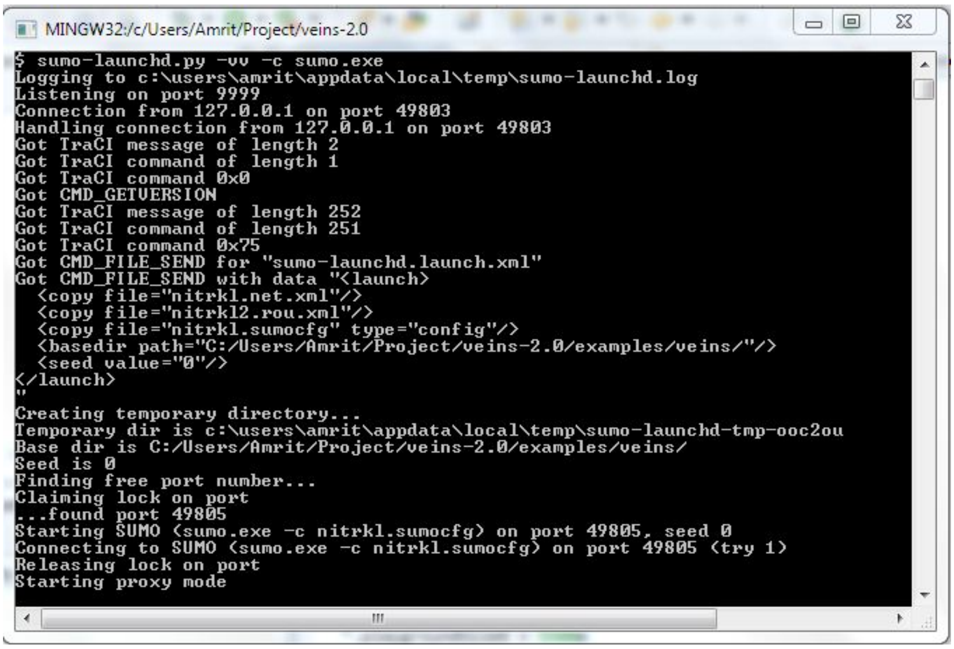


FIGURE 3.11: Opening port for communication between traffic and network simulation

instance of SUMO and proxies requests between OMNeT++ and SUMO figure 3.11 shows this .

3.3.1 Final Simulation

After completing all the above mentioned steps now we can run the simulation in omnet++ The node movement in the network simulation is governed by network file of traffic simulation. Figure 3.12 represents this.

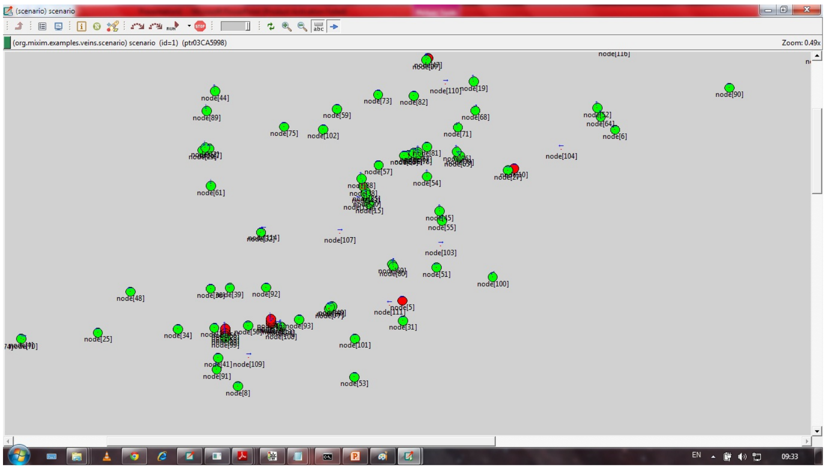


FIGURE 3.12: Network simulation using omnet++

All the information of the communication between vehicle are stored in a trace file.

Chapter 4

Conclusion

Simulation of vehicular movement is done by using road traffic simulation and network simulation. Here we can see that bi-directionally coupled simulation have advantage over the uncoupled simulation, simple traffic simulation cannot is not appropriate for VANET simulation. Here veins provide all the functionality for bi-directional coupling. The above created simulation can be used for various purposes like testing of VANET application and protocols.

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